High-Brilliance X-Ray Source for Protein Crystallography

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Protein crystallography is currently the most powerful method for determining the three-dimensional structures of proteins and other macromolecules. Determination of the three-dimensional structure of macromolecules is of fundamental importance in the area of molecular biology and has considerable potential for application in rational drug design and protein engineering. This method usually requires crystals that are relatively large and that possess a high degree of internal order.

Several microgravity experiments have successfully produced protein crystals that greatly exceed the quality of the best crystals obtained from ground experiments, allowing investigators to significantly improve the atomic structures of these proteins. However, many proteins of significant interest to the scientific community produce only small or weakly diffracting crystals, which, until recently, could only be analyzed using the high-energy radiation of Synchrotron facilities.

Advances in x-ray optics, particularly Kumakhov optics, have been designed and utilized by a team of scientists at MSFC, SUNY, and X-Ray Optical Systems, Inc., to produce new high-intensity x-ray sources. The project is outlined and proceeding in three stages. Initial tests of the stage II lens (fig. 10) conducted at MSFC's

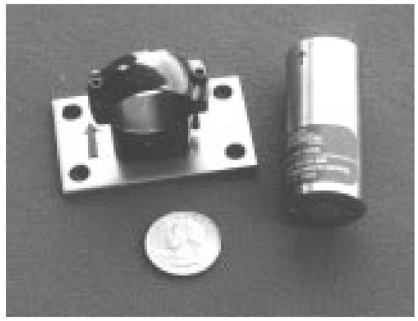

FIGURE 10.—Stage II lens and holder.

Laboratory for Structural Biology indicate that the brightness of the lens/x-ray source combinations is more than 160 times brighter than the conventional rotating anode generator. These systems will provide a tremendous improvement in the rate and quality of collected x-ray diffraction data, and smaller samples of more challenging protein structures may also be pursued. Low-power systems operating at 37 watts have been demonstrated to exceed the brightness of current rotating anode sources by a factor of 2. The low power requirements and high brilliance of this prototype system have important implications for developing an on-orbit x-ray diffraction facility. The numerous other applications for this technology include improved medical imaging.

Ullrich, J.B.; Ponomarev, I.Yu.; Gubarev, M.V.; Gao, N.; Xiao, Q.F.; and Gibson, W.M. 1994. Development of Monolithic Capillary Optics for X-Ray Diffraction Applications in X-Ray and Ultraviolet Detectors. Proceedings of the Society of Photo-optical Instrumentation Engineers, 2278:148–55.

MacDonald, C.A.; Abreu, C.C.; Budkov, S.; Chen, H.; Fu, X.; Gibson, W.M.; Kardiawarman, A.; Karnaukhov, A.; Ponomarev, I.Yu.; Rath, B.K.; Ullrich, J.B.; Vartanian, M.; and Xiao, Q.F. 1993. Quantitative Measurements of the Performance of Capillary X-Ray Optics in Multilayer and Grazing-Incidence X-Ray/Extreme-Ultraviolet Optics II. Proceedings of the Society of Photo-optical Instrumentation Engineers, 2011.

Ullrich, J.B.; Kovantsev, V.; and MacDonald, C.A. 1993. Measurements of Polycapillary X-Ray Optics. *Journal of Applied Physics*, 74:5, 933–39.

Ullrich, J.B.; Gibson, W.M.; Gubarev, M.V.; and MacDonald, C.A., 1994. Potential for Concentration of Synchrotron Beams With Capillary Optics. *Nuclear Instruments and Methods,* A347:401–6.

Gibson, W.M., and MacDonald, C.A. 1994. Polycapillary Kumakhov Optics: A Status Report in X-Ray and Ultraviolet Detectors. Proceedings of the Society of Photo-optical Instrumentation Engineers, 2278:156–67.

Wentink, R.; Carbone, J.; Aloise, D.; Gibson, W.M.; MacDonald, C.A.; Hanley, Q.E.; Fields, R.E.; and Denton, M.B. 1994. Charge-Injection Device Technology: An Imaging Solution for Photon- and Particle-Imaging Applications. Proceedings of the Society of Photo-optical Instrumentation Engineers, 2279.

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